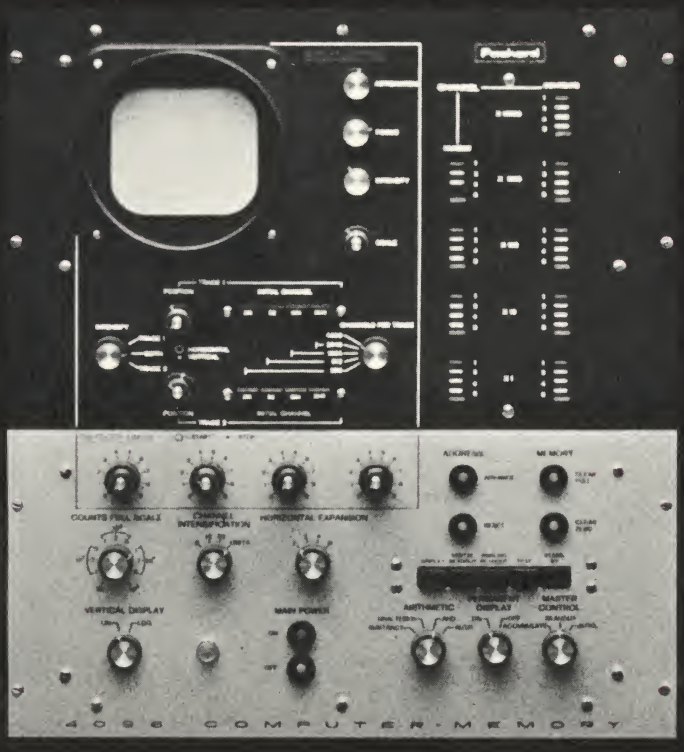
Packard

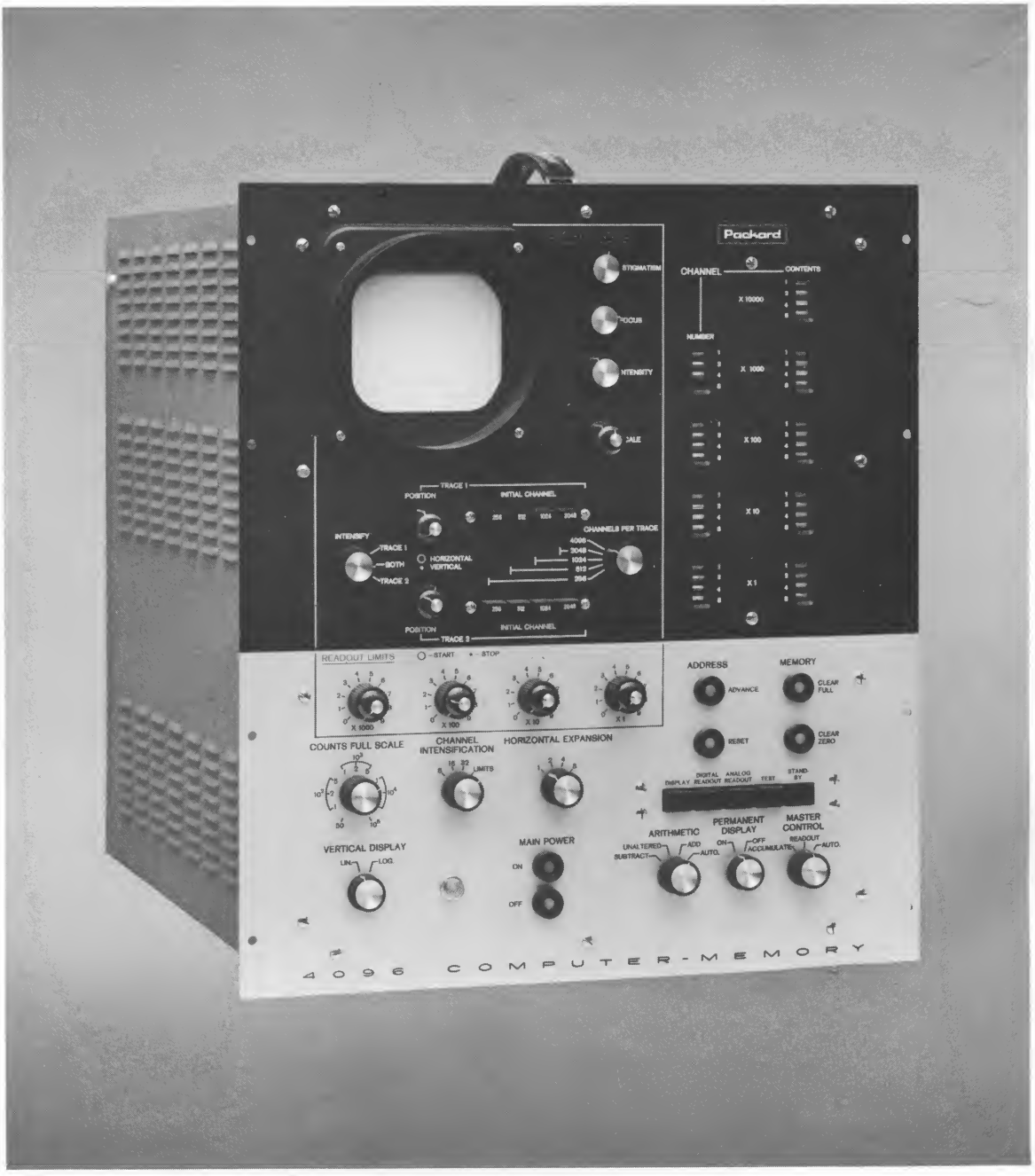
Models 25 and 45

1024 Channel and 4096 Channel

Computer-Memory Units

Bulletin 1041





Models 25 and 45 1024 Channel and 4096 Channel Computer-Memory Units

In complex nuclear physics experiments the researcher is frequently confronted with a number of correlated events which can be described by suitable parameters defining the "dimensions" of the experiment. For example: the energy of a particle, the energy or time-of-flight of another particle related to the first, or the angle between particle trajectories. With the conventional multichannel analyzer, only one parameter can be allowed to vary at a time, and the physicist must repeat the experiment many times to allow the other parameters to take on a range of values.

Packard Multiparameter Analyzer Systems enable the researcher to analyze, sort out and accumulate in a single experiment, simultaneous or correlated values of several parameters. Analyzer systems ranging from the simplest to the most complex configurations may be put together from a range of specially designed modules, all of which have been designed to work together in a variety of combinations.

In developing this versatile analyzer design, Packard has had the benefit of the knowledge and experience of Intertechnique of France and the physics and electronics laboratories of the Saclay Nuclear Center.

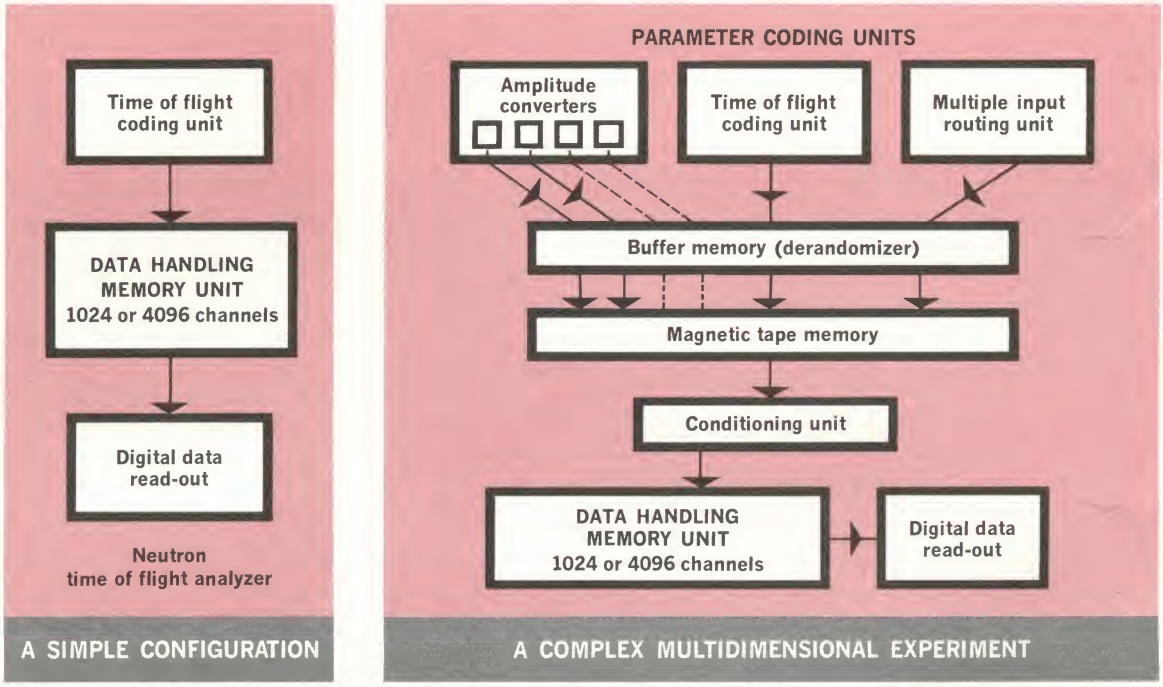
The complex system illustrated on the next page, for example, has been used for many years by leading European scientific laboratories, and each of its elements has been refined through rigorous field testing.

Description of the Instrument

Models 25 and 45 Computer-Memory Units are designed to sort and store information originating from nuclear detector systems. They can be used either to gather data directly or to process information recorded on multitrack magnetic tape. In the former case, the signals from the various detectors are sent to analyzing and routing circuits which control the storage of information in the proper channels. In the latter case, the results of a previously recorded experiment can be classified in the various channels of the Computer-Memory as a function of selected correlations between the data.

The Computer-Memory can be connected to other standard Packard Modules to build up systems such as amplitude analyzers with memory sub-grouping features, time-of-flight analyzers, and multiple-input systems for time correlation analysis (coincidence, anticoincidence), between several events in a multidimensional experiment.

In addition, this instrument may be used as the memory unit in data-processing systems directly related to the experiment under way when preliminary calculations are required, or when it is desirable to perform some data reduction before initiating complete calculations in an electronic computer. The circuitry of Models 25 and 45 Computer-Memory Units is fully transistorized and utilizes plug-in printed circuit boards. Some



of the advantages of this design and construction include:

- Small size and weight
- Low power consumption
- Minimum heating with resultant longer-lived components
- Excellent reliability
- Ease of servicing by simply replacing plug-in circuit boards

Components

Models 25 and 45 consist of the following elements:

- Address registers or scalers
- Magnetic core memory and associated "read" and "write" circuits
- Data register
- Control circuits
- Oscilloscope for visual data display
- Data readout circuits for direct connection to a parallel-type printer or a parallel-to-serial converter for a serial type printer or tape punch. Analog data output is also available for driving a recorder.
- Manual digital front-panel display of any one channel's address number and content (in 1, 2, 4, 8 code).
- Power supply for the electronic circuits

The main storage element in the instrument is a ferrite-core memory with either 1024 or 4096 addresses and a capacity of 10^5 counts for each address.

Since storage is in binary coded decimal, there are twenty cores for each address. The whole memory, therefore, includes:

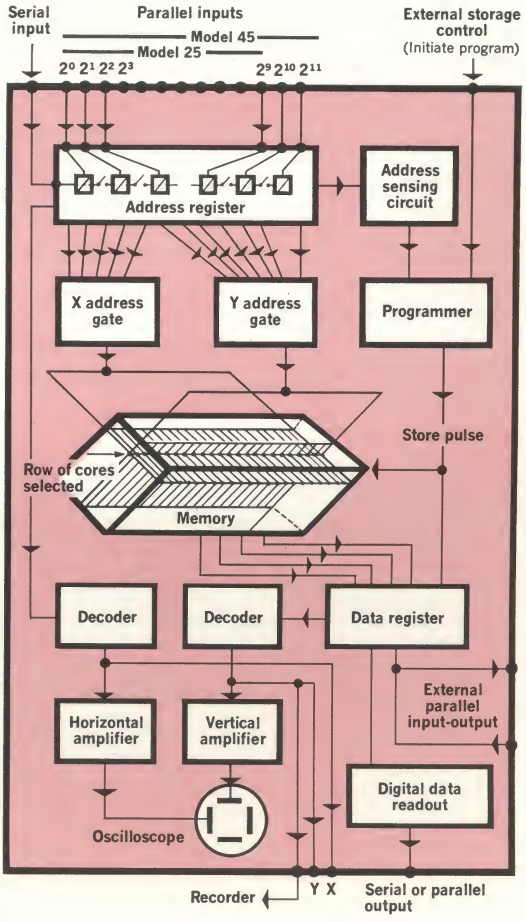
1024 x 20 = 20,480 cores (Model 25)
4096 x 20 = 81,920 cores (Model 45)

arranged on 20 boards in a 32 x 32 or 64 x 64 configuration. The overall access time to the memory (from the leading edge of the "initiate storage" pulse to the end of the memory program cycle) is approximately 16 μsec.

Principles of Operation

The address or channel number where the information is to be stored in the core memory is selected in binary code by positioning the bistables of the "address register" (refer to block diagram). At this selected address the data accumulated in the memory is read out from the memory into the data register in BCD. The information contained in the data register can then be modified as follows:

- add "one"
- subtract "one"
- add "zero"
- reset to zero and, eventually, add a given number by external insertion of data into the data register in parallel and in a binary coded decimal format. This modified number of counts in the data register is then "written back" into the address in the memory.



After storage, the total counts accumulated in the memory at the various addresses (channels) can be viewed on the built-in oscilloscope; they can also be recorded in analog form or printed out digitally.

The Packard Model 45 Computer-Memory incorporates a special and unique permanent display provision which maintains the instrument in a display mode even during accumulation. This feature permits the experimenter to observe the spectrum during accumulation by automatically shifting from a display address register to an accumulation address register whenever an acceptable pulse is processed. Even with very low information arrival rates, excellent analog information is presented on the oscilloscope.

Address Registers

Model 45 contains three separate address registers or scalers. A high-speed binary register is provided for conversion purposes; a second binary register is required for the permanent display, and a third decimal register is used for readout purposes.

Model 25 does not include provision for permanent display and, therefore, contains only the first and third registers listed above. The bistables in the high-speed address register are usually driven in parallel, but it is possible to drive the first high-speed bistable (corresponding to the least significant digit), in a serial configuration. Any number of bistables between 1 and 10 (or 12) can be connected in series, with the remaining bistables being driven in parallel. Resolving time for the serial configuration is less than 0.5 μsec. In the usual case of parallel operation, the experimenter can select several bistables for particular parametric information, and utilize the remaining bistables for other information correlated to the first.

Data Register (or Scaler)

This register is of the binary coded decimal type (1, 2, 4, 8 code) and has a capacity of 10^5 counts. It operates in parallel from the memory during "read" and "write" operations. The register's parallel inputs are also available externally for injecting numbers smaller than 100,000 into the register. Parallel outputs from the data register are also provided externally to read out its content at any particular time.

The data register can be serially driven, operating as a scaler when "one" is added to, or subtracted from the content of a channel during a storage cycle. Switching between ADD and SUBTRACT can be done either manually or by means of an external pulse. When operating as a scaler, the data register's resolving time is less than 1 μsec.

Control Circuits

These circuits control the operating modes of the instrument (storage, display and data readout). In particular, the KEYBOARD SELECTOR controls the sequence of memory "read" and "write" operations as well as the arithmetic operations in the data register.

In the ACCUMULATE mode of operation, the beginning of each storage program cycle can occur either as soon as a pulse appears on the address register or when an "initiate program" pulse is delivered to an input provided for external storage control.

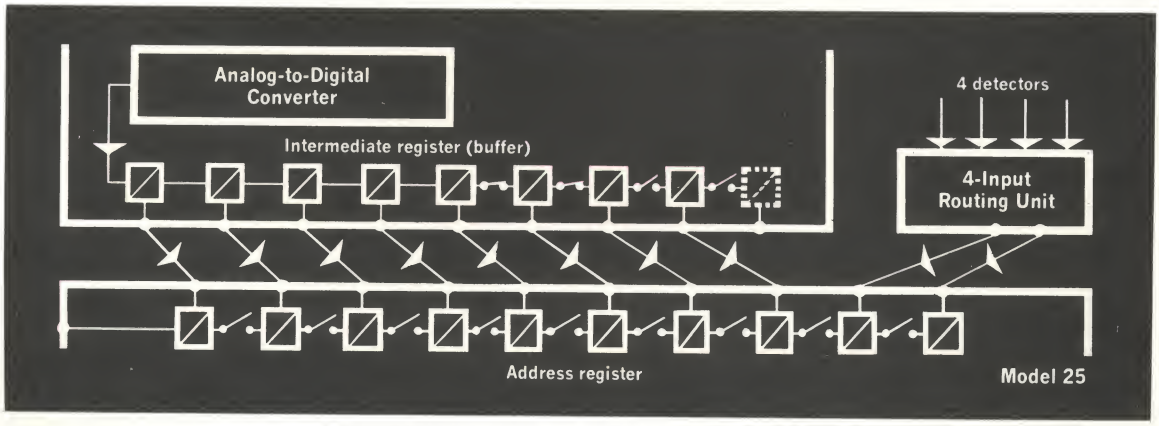
Examples of System Flexibility

Several examples of the flexibility of Packard Analyzer Systems are shown below.

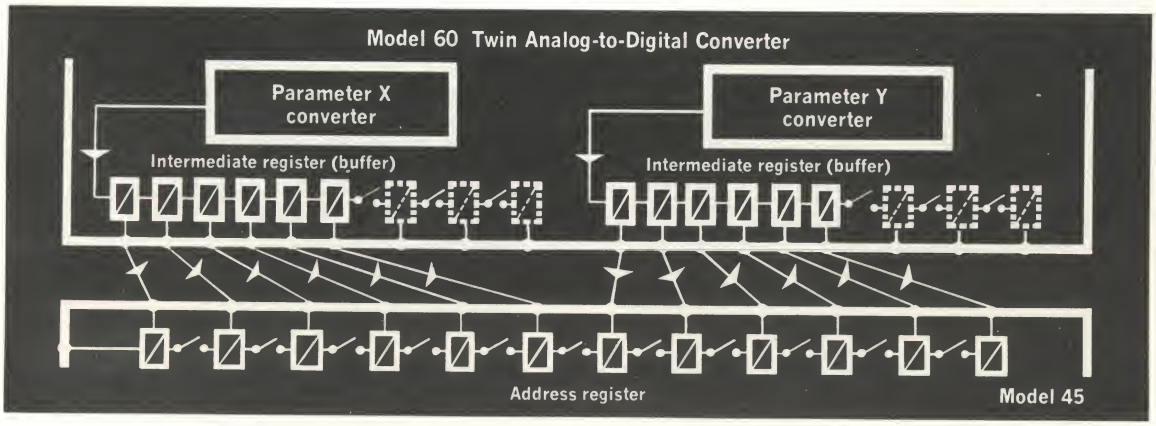
Example 1: In a Model 25 1024 channel unit, the eight least significant bistables are driven by an external converter through eight parallel outputs, while the two remaining bistables are receiving information from detectors through a 4-input selective storage. With this system, the researcher can analyze four separate spectra on a 256 channel basis.

Example 2: In a Model 45 4096 Channel Computer-Memory, six bistables receive information from an external converter (parameter X) while the other six receive information from another external converter (parameter Y). The information is stored in the memory when the two sets of signals appear in the address register simultaneously or according to a particular time correlation. This arrangement represents an X-Y 64x64 channel amplitude analyzer system.

Example 1



Example 2



Data Readout

Data are displayed on the built-in oscilloscope, and can also be automatically plotted out on an external recorder or written out digitally on a typewriter, printer or tape punch.

Oscilloscope Display

Data are displayed as a spectrum on a 5 in. flat-screen cathode-ray tube fitted with an illuminated graticule and a camera mount. Memory contents can be viewed in several ways, as detailed in the table at right.

IN MODEL 25

as a single 1024-channel trace
as two 512-channel traces
as four 256-channel traces

IN MODEL 45

Entirely:
as a single 4096-channel trace
as two 2048-channel traces

Partially:
as two 2048-channel traces
as two 1024-channel traces
as two 512-channel traces
as two 256-channel traces

Traces can be shifted independently in both horizontal and vertical directions to allow comparisons. In addition, two traces can be made to represent the same memory subgroup, permitting comparisons between sections within a subgroup.

A "magnifying" switch is provided to expand the horizontal scale by factors of 2, 4 or 8. With the maximum expansion it is

Figure 1: Random coincidence experiment using cobalt-60 and cesium-137. Cobalt-60 input drives the first six address register stages and the cesium-137 input is used to drive the last six address register stages. The composite 4096-channel curve shown portrays a cesium-137 envelope (complete with barium X-ray peaks) which is generated by 64 cobalt-60 spectra.

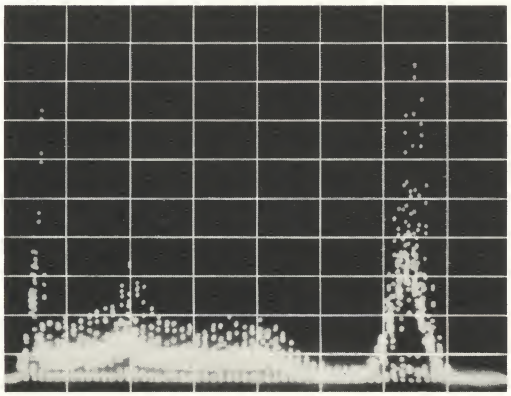
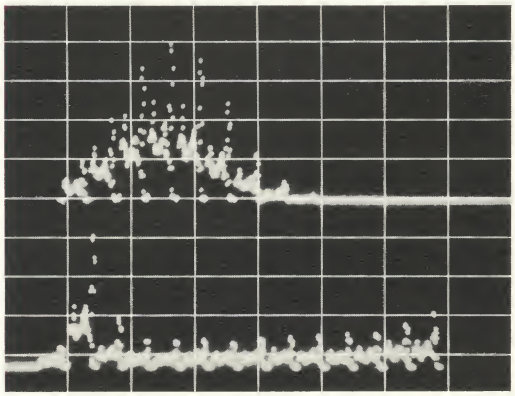


Figure 2: Two 1024-channel portions of the spectrum contained in Fig 1. The upper trace embodies the 662 kev cesium peak and represents channels 3072 through 4096. The lower trace embodies the 33 kev barium X-ray peak and covers channels 0 through 1024.



possible to display any 32-channel sequence over the full width of the oscilloscope.

For easier spectrum identification, any 256-channel subgroup in Model 25 can be made brighter than the others on the oscilloscope. In Model 45 when the spectrum is viewed in two traces, one of them can be made brighter than the other. In addition, the experimenter can intensify every 8, 16, or 32 channels, or any two channels of special interest. The latter function is also associated with the printout cycle as it permits a digital selection of the first and last channels to be printed or punched out. Vertical full scales of 50, 100, 200, 500, 1,000, 2,000, 5,000, 10,000, 20,000, 50,000 or 100,000 counts can be switch-selected.

Analog Readout

The analog output signal is always obtained by decoding in the three most significant decades. Accuracy of the analog signal is between 0.1% and 1% depending on the number decoded. Output voltage to the recorder can be adjusted from 25 to 100 mv full scale. Recorder full scale corresponds to the setting of the oscilloscope vertical selector switch, namely 50, 100, 200, 500, 1,000, 2,000, 5,000, 10,000, 20,000, 50,000 or 100,000 counts. For strip chart recorders, address markers of every 8, 128, or 1024 channels are provided.

An analog voltage proportional to address number is available for X-Y plotting. Recording speed is at 1 channel per second. By means of external synchronizing, it is possible to provide analog information at rates up to 1,000 channels per second.

Digital Readout

The address number and the number of counts in each channel are available as parallel outputs in binary decimal code (1, 2, 4, 8). These data can be read out on digital display units or printed out on a typewriter, printer or tape punch.

Digital display of channel and count information in 1, 2, 4, 8 code is available as a built-in feature on the front panel of the instrument. Channels can be advanced manually for viewing the data. If decimal display is required, the Model 75 Readout Indicator can be supplied. This unit transforms the parallel 1, 2, 4, 8 code into decimal code.

Figure 3: Magnification of the traces shown in Fig. 1; the familiar twin peaked structure of the cobalt-60 spectrum is now discernible. These traces represent two 256-channel spectra; the upper one corresponds to channels 3328 to 3584 (representing trailing edge of the 662 kev cesium-137 photopeak), while the lower trace represents channels 3072 to 3328 (corresponding to leading edge of the 662 kev cesium-137 photopeak).

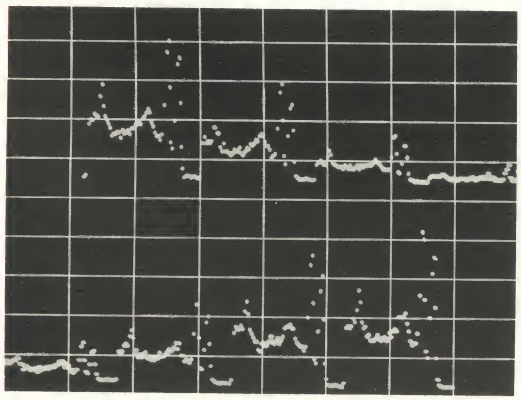
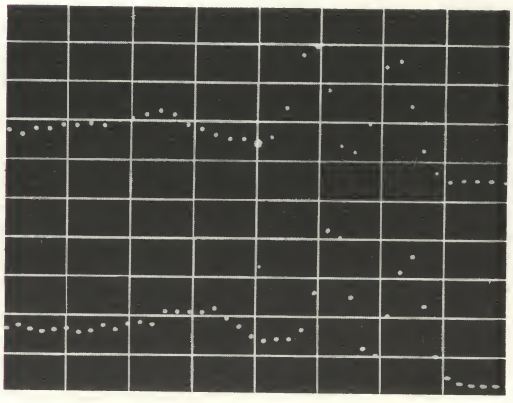
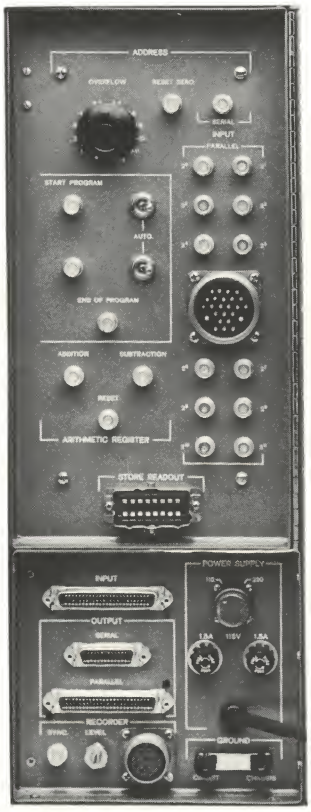


Figure 4: Illustration of the tremendous magnification capabilities of the Model 45 Computer-Memory by presenting two 32-channel traces across the full 5″ width of the 'scope. Both traces clearly show a single portion of cobalt-60 spectrum. In the upper trace, two readout limits have been chosen corresponding to the beginning of the leading edge of the 1.17 kev Co-60 peak and the peak itself. Readout limits may be chosen to represent any two channels out of the 4096 available.



General Features



External Inputs and Control Signals

Inputs to the high speed address register:

10 inputs (Model 25) or 12 inputs (Model 45) for parallel control of the address register.

1 input for serial activation of the address register.

A 10 (or 12) position selector switch can separate bistables into both a serially connected group and a group of parallel inputs.

1 input for "zero" reset of the address register

1 output for "End-of-Memory Cycle"

1 input for "Write"-back into memory signal

1 input for "zero" reset of data register

1 input for external "initiate program" control

2 inputs for external ADD or SUBTRACT mode control

1 input for external synchronization of recorder readout

20 parallel inputs and 20 parallel outputs of the data register

13 (Model 25) or 14 (Model 45) parallel outputs of the decimal address scaler

1 analog data output including a switch for starting a recorder

1 input for external switching of ACCUMULATE-READOUT modes

1 input for CLEAR MEMORY signal

Operating Modes

a ACCUMULATE

The number of counts in the channel selected by the input circuits may be increased or decreased by "one" (or "zero") in this mode. The memory program cycle is initiated either automatically as soon as information appears in the address register, or by an external control signal which may be delayed for complete positioning of the register. With either Model 25 or Model 45, the spectrum can be viewed during accumulation if the information rate is sufficiently high. Model 45 also allows visual observation during accumulation at low information arrival rates by using the ACCUMULATE WITH PERMANENT DISPLAY mode described below.

b READOUT

Oscilloscope Display—Accumulation is inhibited in this case. The memory contents are read out into the data register and written back into the memory, channel by channel. An oscillator provides the fast scanning of the consecutive addresses and the "initiate program" signal at each channel position.

Test—A TEST mode is provided to check on the operation of critical digital circuits. This mode "adds" or "subtracts" a single count to each channel in sequence, resulting in a continuously rising (or falling) horizontal line on the oscilloscope.

Analog Data Readout—A low frequency oscillator drives the memory circuits in a manner similar to that described for the OSCILLOSCOPE DISPLAY mode, but every channel is examined for approximately 1 sec. External synchronization is possible up to 1 kc for use of fast recorders.

Digital Data Readout—Scanning of the contents of each channel is controlled by the printer or tape punch, or by manual control when using a readout indicator. Printout on the digital readout units occurs during scan.

c ACCUMULATE/READOUT BY EXTERNAL SIGNALS

Switching from ACCUMULATE to READOUT mode (for data printing or recording), and back from READOUT to ACCUMULATE can be controlled by external signals timed to follow a preset program.

d ACCUMULATE WITH PERMANENT DISPLAY

Permanent Display is a unique feature found only in the Packard Model 45 Computer-Memory. It permits the experimenter to view the spectrum while it is being accumulated, even when the information arrival rate is very low. In this particular mode, the average dead time is increased slightly (21 μsec instead of 16 μsec). The circuits operate in OSCILLOSCOPE DISPLAY mode as long as there is no information being accumulated. When information comes in, the ACCUMULATE mode is automatically switched on.

Power Supply

A saturated core transformer stabilizes circuit voltages to ±1% for ±15% line variations.
Line voltage.....115 volts, 60 cycles
Power.....100 watts

Dimensions and Weight

21 in. high x 16½ in. wide x 27 in. deep.
Weight: 130 lbs.

General Specifications

Memory

Model 25.....1024 channels
Model 45.....4096 channels
Type.....Ferrite core
Capacity.....10^5 counts per channel
Access time..... approximately 16 μsec.

Electronics

Fully transistorized, built on standard plug-in printed circuit boards

Temperature Range

50°F to 110°F ambient

Binary Address Register

Model 25.....10 stages
Model 45.....12 stages

Input...both parallel and serial provided
Resolving time in serial input configuration.....less than 0.5 μsec.

Data Register

Type. Binary coded decimal. (1, 2, 4, 8 code)
Capacity.....100,000 counts
Operation.....ADD or SUBTRACT
Input.....either serial or parallel depending on function performed
Output.....parallel
Resolving time.....less than 1 μsec

Oscilloscope Display

Memory contents are displayed on a 5-in. built-in cathode-ray tube during and after accumulation. Illuminated graticule and camera mount provided. The memory contents can be viewed as follows:

Model 25
single 1024-channel trace
two 512-channel traces
four 256-channel traces

Model 45
single 4096-channel trace
two 2048-channel traces
two 1024-channel traces
two 512-channel traces
two 256-channel traces

Traces can be independently shifted in both horizontal and vertical directions.

Additional horizontal scale expansion by factors of 2, 4, or 8 is provided for any selected subgroup.

Vertical full scale of 50, 100, 200, 500, 1,000, 2,000, 5,000, 10,000, 20,000, 50,000 or 100,000 counts can be switch-selected.

Spot intensification of the following channels is provided:

Any 2 channels selected by four double selector switches (units, tens, hundreds, thousands).

Every 8, 16, or 32 channels

Any 256-channel subgroup (Model 25)

Either of two traces (256, 512, 1024, or 2048 channels) in the Model 45

Manual Digital Display

Address number and content can be displayed for any channel:

in 1, 2, 4, 8 code on the front panel

in decimal code on a Model 75 Readout Indicator

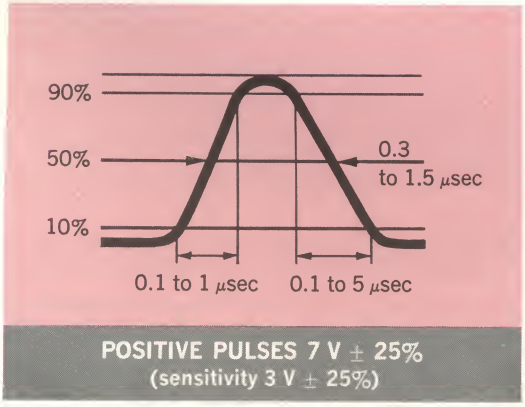
Address advance is by pushbutton control, the first channel displayed coinciding with the first intensified spot on the oscilloscope (selected by the four selector switches for units, tens, hundreds, thousands).

Other Data Readout Modes

Analog outputs are provided to drive a pen recorder. Digital outputs are provided for either a parallel type printer, or a serial printer or tape punch.

Data print-out can be limited to only those channels lying between the two intensified spots selected by the four double selector switches (see OSCILLOSCOPE DISPLAY). This is a unique feature of the Packard Computer-Memory.

Interconnecting Signals



All input pulses to the Computer-Memory are standardized as follows:

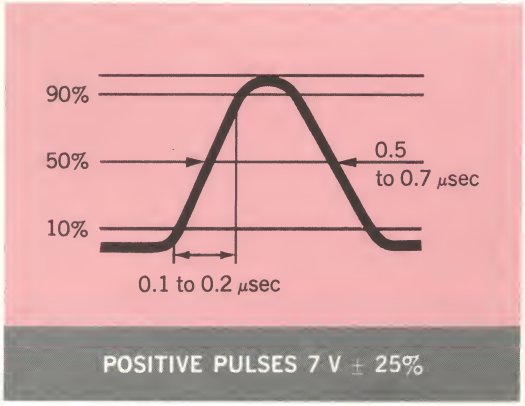
Pulse source impedance less than 1,000 ohms

Input impedance greater than 10,000 ohms with at most 60 pf in parallel

Note 1—Pulses of ±1 volt will have no effect, whatever their rise time.

Note 2—The parallel inputs to the address register can be dc driven.

End of Program Pulses



End of program pulses have the following specifications:

Output impedance less than 100 ohms

Note—Digital information output is provided as parallel dc levels:

For binary "zero" state.....−4 to −3 volts
For binary "one" state.....+2 to +3 volts
Current.....1 ma available per binary digit

Accessories

Many input and output accessories may be used with Models 25 and 45, increasing their versatility and utility to the experimenter.

Input Devices

Model 60 Twin Analog-to-Digital Converter featuring parallel outputs and operating as 32, 64, 128, 256, 512 or 1024 channel analyzer. Converters can operate separately or coincidence-controlled by one another.

Model 61
1 μsec Neutron Time-of-Flight Encoder

Model 62
50 nanosecond Neutron Time-of-Flight Encoder

Model 63
10 nanosecond Neutron Time-of-Flight Encoder

Model 65
Two-Input Selective Storage

Model 66
Four-Input Selective Storage

Model 67
Sixteen-Input Selective Storage

Model 68
Thirty-two Input Selective Storage

Output Devices

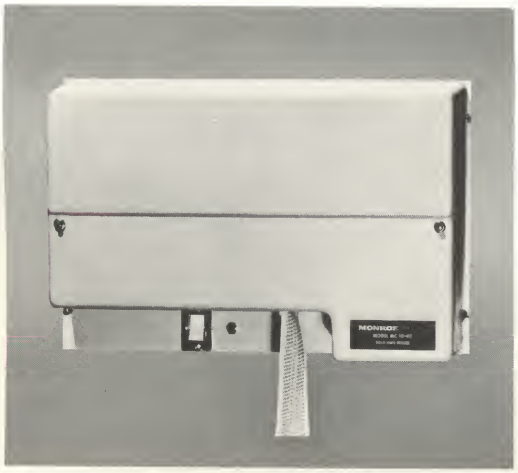
MODEL 70
Parallel-to-Serial Converter

This converter is used to serialize information from the Analyzer and drive either the Model 91 Typewriter or the Model 92 Tape Punch. Plug-in board logic makes Model 70

readily compatible with the user's code requirements. A switch is provided to permit selection of either of the two serial outputs. Data is in BCD 1, 2, 4, 8 code at a rate compatible with the output device being driven.

MODEL 90
High-Speed Printer

This device prints out data from the Analyzer at the rate of 17 channels per second, presenting results on a 2¼-in. paper tape. Model 90 is a high-speed parallel printer which connects directly to the basic Analyzer without need for data converters. A Monroe MC-10-40 Digital Printer is used as the printer.



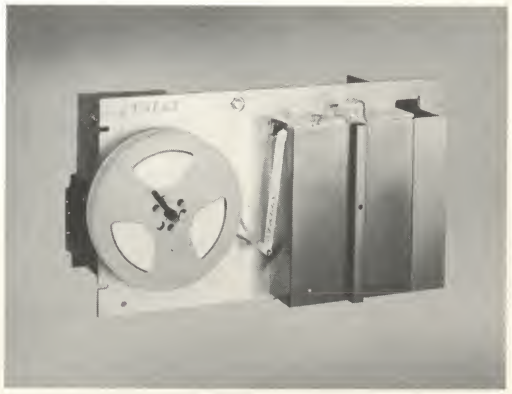
MODEL 91
Output Typewriter

The output typewriter prints out digital information from the Analyzer at the rate of one channel per second. Ten channels are printed across the width of a sheet, giving a compact, easy-to-file document for each printing run. An IBM Computer Typewriter is offered as the standard output device.

The Model 91 requires a Model 70 Serial Converter to read data from the Analyzer.

MODEL 92
Tape Punch

Data from the Analyzer can be read out on punched tape for subsequent processing by a computer. The Model 70 Serial Converter is required to transfer the data to the tape punching unit. Model 92 operates at speeds up to 60 characters per second and perforates as many as eight code channels. The standard tape punch is the Tally Model 420.



Other output devices which may be used with Model 25 and Model 45 Computer-Memory Units include the Model 93 X-Y Plotter, and the Model 50 Magnetic Spectrum Reducer.

Packard

PACKARD INSTRUMENT COMPANY, INC.

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Model 60 Twin Converter

This transistorized instrument includes two converters of the same type as those included in the Packard Models 15 & 16 400 Channel Analyzers, but adapted to 32, 64, 128, 256, or 512 channel conversion, and designed primarily for the use with Packard Models 25 and 45 1024 and 4096 channel analyzers. Each of the converters includes an address register used as intermediate storage element. The result of each conversion is transferred in parallel to one of the registers of the multiparameter analyzer.

The two converters can be used independently and, in this case, the transfer of the data from each intermediate register to the analyzer can be made as follows:

1. automatically as soon as the conversion is made, with an off time varying with the analyzed amplitude.
2. automatically after a fixed off time of longer duration than the longest conversion time. The duration of this off time is selected by the user.
3. by an outside signal

These two converters when used with a multiparameter analyzer constitute the main part of a three-dimensional experiment and permit analysis of the two spectrums governed by each other. In this case, the transfer command from the two amplitude converters to the analyzer can be given as indicated by cases 2 and 3, above. In case 1, the slowest of the two conversions automatically controls the transfer.

The instrument is offered in a standard rack mountable chassis and includes the following components:

two linear amplifiers
two 512 channel converters, usable also as 256, 128, 64, or 32 channel converters.
two address registers, each with a capacity of 512, used as intermediate registers.
the control and command circuits or the various transfer systems.
a power supply magnetic-resonance transformer.

Upon request, this unit will be supplied with a single amplifier, converter address register configuration.

Technical Characteristics

Analog to Digital Converter

Signal Input . . . positive pulses 0 to 8 volts
Input Rise Time . . . . . greater than 0.6 sec.
Conversion gain . . . . . 8, 4, 2 and 1 volt / 64 channels
Conversion time . . . . . address selection by 2 mc pulses driven from 8 mc crystal oscillator
Upper Level Adjustment . . . . 0.2 to 10 volts by 10-turn helical potentiometer. (This adjustment permits rejection of pulses with energies higher than the region of interest, thus eliminating off-time caused by such pulses. The adjustment is useful for observation of low energy areas of spectra during high counting rates.)
Threshold (Channel Zero) Adjustment . . 0 to 8 volts by a 10-turn helical potentiometer. (This adjustment shifts the origin of the energy scale and permits a detailed examination of the high energy region of a spectrum without overburdening the analyzer with the dead times associated with low energy pulses.)
Lower Level Adjustment . . . 0.15 to 8.0 volts adjustment. (This adjustment eliminates pulses lower than the selected level, and the off-time due to these pulses, without shifting the origin.)
Converter blocking input . . . . . external positive pulses greater than 8 volts.
Prompt coincidence (anticoincidence) input . . . external negative (positive) pulses greater than 8 volts.
Delayed coincidence (anticoincidence) input . . . external negative (positive) pulses greater than 8 volts.

Linear Amplifier

Input Polarity . . . . . positive going
Input Rise time (optimum) . . . . . 0.3 sec.
Maximum gain 400
Coarse Attenuator control . . . 1, 2, 4, 8, 16, 32
Fine Attenuator control . . . . 1 to 2 by means of 10-position selector switch
Output . . . . . positive pulses, maximum amplitude approximately 8 volts

When used with either the Packard Model 25 1024 channel analyzer or the Packard Model 45 4096 channel analyzer in a 64 x 64 configuration the following system specifications apply.

Temperature range . . . 50° to 105° F. ambient
Long term stability . . . . Less than 1 channel drift over 24 hours
Zero Drift . . . . Less than 0.4% of full scale per 20° F. Less than 0.2% of full scale per 10% line change.
Gain Shift . . . . Less than 0.4% change in the number of channels between two peaks per 20° F. Less than 0.2% change in the number of channels between two peaks per 10% line change.
Intergral Linearity . . . better than 0.25% over the top 99% of the range.
Differential Linearity . . . better than 2% over the top 99% of the range
Maximum counting rate . . . Less than 0.4% of full scale shift of test pulses injected at photomultiplier anode at 5×10^4 pulses per sec. of Co-60 with 1.0 mev full scale.

Power Supply

The two converters have a common power supply. A regulating transformer delivers 1% regulated voltage for a line variation of 15%. Circuits requiring better regulation are supplied from Zener stabilizers. Line voltage: 115 volts, 60 cycles.
Power Consumption: 30 watts

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